Implementation of the trinity of the control system based on OPC

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Abstract:*The WinCC+PLC control system is a typical real-time control system. Many Engineering colleges Introduce corresponding control experiments in relevant courses to enhance the students' understanding of this knowledge. But it needs both venues and funds and has unsafety factors to equipped with varieties of experimental subjects for the laboratory. This paper gives a very good solution to this problem by introducing MATLAB virtual control object in the classic WinCC+PLC control system. What's more,it realizes the seamless connection between the MATLAB and the WinCC+PLC control system after analysing how to make the PID controller in STEP7 .*
Key words: *OPC technology; MATLAB; WinCC; real-time control; simulation*

I. Introduction

It is essential to collect and monitor field data completely and effectively real-time in industrial process. WinCC is a man-machine interface (NMI) software to solve the visualization and control tasks in the production process and process automation by which to coordinate visualization, report, collection and archiving process data and applications for users the freedom todefine the integration provides a system module . Moreover, WinCC provides a special channel which is used to ensure the communication with SIMATIC S5, S7 and 505 series of PLC be convenient and efficient.Therefore, so,the WinCC+PLC control system has gradually become the classical control system in kinds of industrial processes. MATLAB is typically limited by the off-line simulation.[1] In order to combine with real-time control objects,we can under the help of the software WinCC by OPC technology(OLE for Process Control, OLE used in the process of control) [2] to make the three communicate and connect to the realization the seamless connection between MATLAB and the control system WinCC+PLC (STEP7) , so as to establish the control system three –in-one.

II. OPC technology

Before the emergence of OPC, every application software developer has to write the special interface function in order to access the data information of the equipment . what's more,that the different kinds of equipment and the equipments upgrade frequently has brought user and software developer a huge burden of work. The emerge of OPC may well solve this problem. OPC takes the Microsoft's OLE/COM and DCOM mechanism as the communication mechanism of application and takes client / server model [3], so as to give the mission of developing access interface to the hardware manufacturer or the third party manufacturers and present to the user in the form of OPC server, solving the contradiction of soft/hardware manufacturers, completing the systemintegration, improving the openness andinteroperability of the system. The OPC server is responsible as data suppliers and provides necessary data to the OPC client; the OPC client is the user of data, processing data provided by OPC server. When using OPC,there always includes the OPC service and the OPC client. OPC server is usually designed by the user, as long as compliance with the OPC data interface protocol can realize data acquisition from the OPC server . A OPC client can beconnected to one or more OPC servers, and multiple OPCclients can also connect to the same OPC server [4].

III.   Three-in-one control system

This control project selects water level in tank as the control object as tank level   is often used as the object of study in the related experiments because it has the characteristics of large time delay and nonlinear .The principle of control system is shown in figure 3-1:
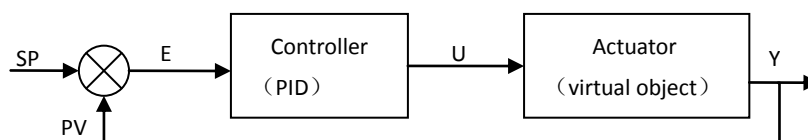

Fig.3-1 The diagram of control Principle   of virtual monitoring system

The object request goal setting value is SP, the working of the system goal is through the establishment of the simulation platform to make the error value E   between set value SP and the return value PV change to be smallest and to monitor the key control quantity at the same time. In the virtual monitoring system, the PLCsim is used to virtual as the controller S7-300PLC, the control algorithm adoptted PID control is realized by STEP7 programming. The controller's output value the operating variables U is transmitted over the MPI channel in STEP7 to WinCC. WinCC works as a OPC server and passes the value to the OPC client MATLAB. MATLAB client reads the numerical U from WinCC by OPC protocol and   sent the value to the actuator, which is the virtual object with time delay, then get the control variable Y of the system. In this system, time delay object is founded through the MATLAB simulation. The MATLAB will also return the value of Y at every time to the comparator, which makes the whole system to form a closed loop control.

IV. The Design and verification of the system

4.1The design of the controller

In the continuous system, the signal is analog signal, the   output   of the controller of PID controller is maked up by proportion item,integral item,differential item and the item output initial[4],   this can be expressed by formula type 4-1:

$$mv(t) = k_c \left[ev(t) + \frac{1}{T_I} \int ev(t)dt + T_D \frac{dev(t)}{dt} \right] + M \qquad (4\text{-}1)$$

In the formula, ev (t) is the input of the controller, the mv (t) is the output of the controller, M is the initial loop output value, k_c is the PID loop gain, T_I and T_D are respectively the integral time and differential time.

Take the rectangular integral on the integral part to approximate the exact part, use the method of difference on differential part to approximation calculation, then type 4-1 changed into:

$$M_n = K_c[(sp(n) - pv(n)] + K_C \left({}^{T_S}/_{T_I} \right) [sp(n) - pv(n)] + MX$$

$$+ K_C \left({}^{T_D}/_{T_S} \right) [sp(n) - pv(n)] \qquad (4\text{-}2)$$

After Completing the digital of PID controller , PID controller can be programmed to work. What Needs to be pointed out[5] is that the scanning cycle of general PLC roughly only several ms to tens of ms, for the system which requires long sampling period , the frequency of PID calculation is too fast so unnecessary burden showed to the CPU which will make the scan cycle of PLC increased easyly   then slow the response. For this kind of physical value as levelwhich changes slowly, the difference between before and after the two calculationerror is very smalland even may be less than the error of the fluctuations in the value, this may

have the result of failure in differential calculation. So wu take the way of structured programming. As shown in Fig.4-1,we use FB1 block to program the PID controller and specify it
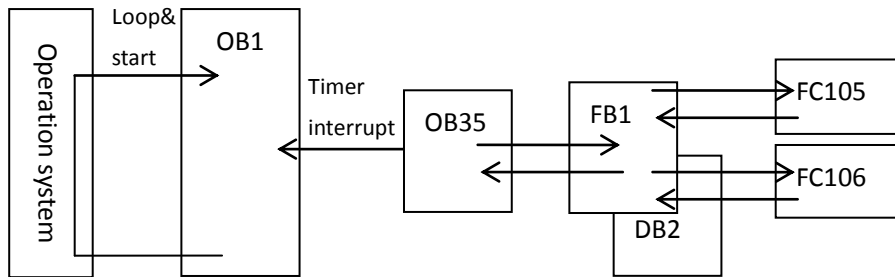

Fig. 4-1 The hierarchical structure of block call

a background data block when it is called. During process of the PLC operation, the block OB1 works as the interface between the operating system and the user program and immediately keep scanning and operation as the PLC startted. The block OB35 is a circular terminaltissue block of each time interval which will work for a time default 100ms, the block FB1 is called in the block OB35, then the cycle time of OB35 execution is the operation time of the PID controller. The block FB1 calls the block FC105 and the block FC106 .Confined to the length, the program is not listed. The complete program file is shown in fig.4-2.
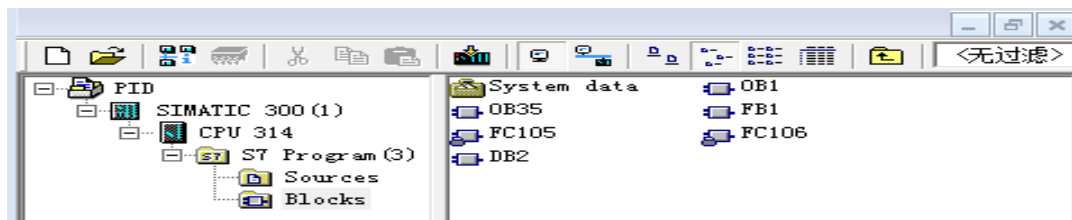

Fig. 4-2 The figure of edited program blocks

4.2The implementation of Virtual control object

After studying on water level structure, object control function is obtained by demonstration, just as:

$$G_p(s) = \frac{e^{-4\tau s}}{T_p s + 1} \tag{4-1}$$

Among them, $\tau = 20, T_p = 60$, adding the zero order holder and use Z transform into the type to discrete the object, then type 4-1 changes into:

$$\frac{Y(z)}{U(z)} = (1 - Z^{-1})Z^{-4}\left[\frac{1}{1 - Z^{-1}} - \frac{1}{1 - \sqrt[3]{e}Z^{-1}}\right] = \frac{0.284Z^{-5}}{1 - 0.716Z^{-1}} \tag{4-2}$$

Converte it to discrete equation, then type 4-2 can be expressed as:

$$Y^*(t) = 0.716Y^*(t - T) + 0.284U^*(t - 5T) \tag{4-3}$$

It is

$$Y^*(nT) = 0.716Y^*[(n - 1)T] + 0.284U^*[(n - 5)T] \tag{4-4}$$

From the type can be clearly seen:the current output value Y is relevented to the previous moment output value Y and the the control value U at 5 moments before.

In MATLAB according to the OPC communication processsprogramming ,inorder to realize the MATLAB as the OPC client to communicate with OPC server, it is need to create a client object in MATLAB and establish a connection with the server and add objects, groups and items and set the Property of groups and items. The program is divided into 3 parts: the MATLAB to read OPC data server data program (shown below), MATLABwrites data to the OPC server and display subroutine call back function. The key procedures

are as follows:

```
Server=opcda('localhost','opcserver.wincc');
connect(Server);
group=addgroup(Server);
Item1=additem(group,'cyd');
set(group,'updaterate',20);
set(group,'RecordsAcquiredfcncount',2);
set(group,'Recordstoacquire',60);
set(group,'datachangeFcn',@mydisplay);
start(group);
wait(group);
```

4.3 The configuration design of WinCC

WinCC configuration design mainly includes three aspects that are the interface settings, the variable design and the control screen design. The interface setting realizes the communication between WinCC and STEP7, the variable design makes data transmission in the communication between WinCC and STEP7 in the control system, the control screen design can show the real time change of the value. in the control system . Finally, the run of the system integration is completed, the result of running the system is showned in fig.4-3.
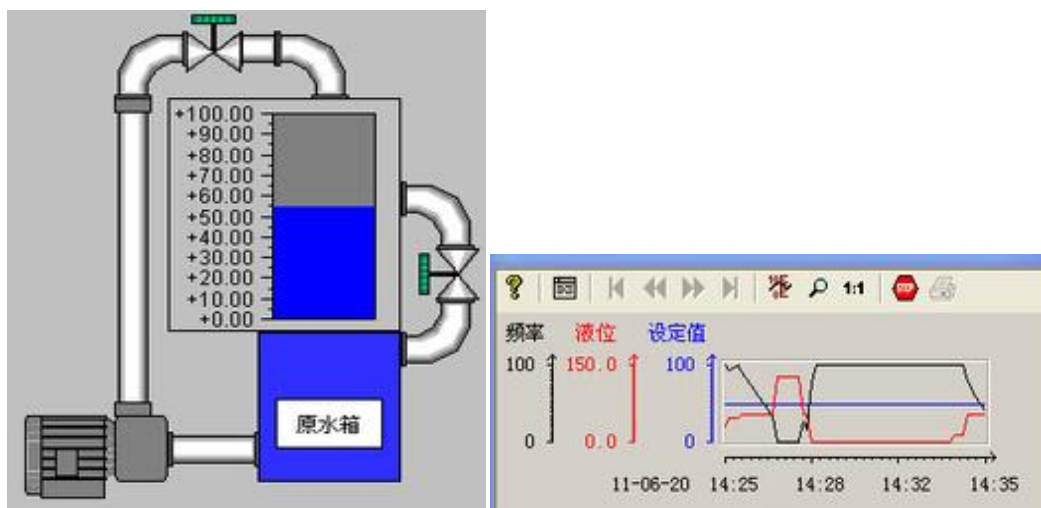

Fig.4-3 the running result of the system

V. The Conclusion

After the birth of OPC technology, it has been supported by many automation hardware and software enterprises [6]. This paper establishes a complete control system based on OPC technology with WinCC, MATLAB and STEP7 three-in-one and use this system to monitor the control of virtual controlled object. With the promotion and popularization of the control module based on OPC standard , it not only makes the control becomes simple, also makes the access to the process data easier. The use of MATLAB for simulation of the virtual object solves the problem that a lot of school laboratory are short of equipments. With the use of MATLAB,as long as the transfer function is known, the control object can be applied to simulate. By this way, virtual the damage control object or expensive control object can not only save money but also save time.

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